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Preliminary evaluation of VTA effectiveness to protect runoff water quality on small pork production facilities in Texas

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Executive Summary

Federal law requires all animal feeding operations to manage manures and wastewater by-products in a manner that is protective of waters of the U.S. As a result, the Texas State Soil and Water Conservation Board (TSSWCB) encourages animal feeding operations to voluntarily participate in the agency's Water Quality Management Plan Program. Historically, limited participation of the pork industry has occurred largely due to logistical and operational issues on smaller operations. Smaller pork facilities generally operate on smaller tracts of land that do not support traditional animal waste management systems such as waste storage ponds, treatment lagoons, and significant expanses of land application acreage.

This project was initiated by the U.S. Department of Agriculture–Agricultural Research Service and Texas Water Resources Institute, with funding from the TSSWCB, to evaluate an alternative wastewater treatment system that includes (1) manure scraping and offsite hauling and (2) a vegetated treatment area (VTA) to treat runoff and wash water prior to leaving the VTA. It is anticipated that this evaluation will provide the scientific basis for considering this system for inclusion as an approved practice in the WQMP Program.

The demonstration and evaluation of the VTA system was initiated at four small pork production facilities in Bell, Bexar, Brazos, and Robertson Counties. Water quality monitoring stations were established at: 1) adjacent control sites, 2) below pens and barns to quantify water quality leaving the facility prior to treatment in the VTA, and 3) at the VTA outlet to quantify effectiveness of the VTA in treating runoff. Event mean concentrations for *E. coli*, nitrogen and phosphorus were determined for each rainfall runoff and pen/barn washing event. Soil sampling was also conducted to assess nutrient accumulation and movement within the VTAs.

Preliminary data collected suggest that VTAs may reduce *E. coli* concentrations by almost an order of magnitude. This preliminary data is encouraging; however, continued assessment of VTA effectiveness in 2013-2015 will provide the robust data required to make a thorough assessment of this practice as an alternative wastewater treatment system for small pork production facilities.

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List of Acronyms and Abbreviations

AFOs	Animal feeding operations
ARS	United States Department of Agriculture – Agricultural Research Service
CAFOs	Concentrated animal feeding operations
cfu	Colony forming units
CNMPs	Comprehensive nutrient management plans
EPA	United States Environmental Protection Agency
FOTG	Field Office Technical Guide
GBRA	Guadalupe-Blanco River Authority
N	Nitrogen
NH4-N	Ammonium-Nitrogen
NMPs	Nutrient management plans
NO2-N	Nitrite-Nitrogen
NO3-N	Nitrate-Nitrogen
NPDES	National Pollutant Discharge Elimination System
NPS	Nonpoint source pollution
NRCS	United States Department of Agriculture - Natural Resource Conservation Service
P	Phosphorus
PO4-P	Ortho-Phosphate
QAPP	Quality Assurance Project Plan
QPRs	Quarterly progress reports
SAML	Texas A&M AgriLife Research Soil and Aquatic Research Laboratory
TCEQ	Texas Commission on Environmental Quality
TPDES	Texas Pollutant Discharge Elimination System
TSSWCB	Texas State Soil and Water Conservation Board
TWRI	Texas Water Resources Institute
VTA	Vegetated Treatment Area
WQMP	Water Quality Management Plan

Introduction

Project Background

On December 15, 2002, the Administrator of the United States Environmental Protection Agency (EPA) signed the final rule regulating concentrated animal feeding operations (CAFOs). In this rule, it reinforced the need for all animal feeding operations (AFOs), regardless of whether they are defined as CAFOs and required to operate under the coverage of a National Pollutant Discharge Elimination System (NPDES) permit, to manage manures and wastewater by-products in a manner that is protective of waters of the U.S. The requirement for nutrient management plans (NMPs) and the recommendation that all AFOs obtain comprehensive nutrient management plans (CNMPs) was a key strategy for achieving maximum protection. As EPA has delegated the NPDES program to the State of Texas, the Texas Commission on Environmental Quality (TCEQ) has adopted the Texas Pollutant Discharge Elimination System (TPDES) under administrative rule and certain management practices and technical requirements specific to unpermitted AFOs in Texas Administrative Code §321.47.

In Texas, the Texas State Soil and Water Conservation Board (TSSWCB), the agency responsible for the management, prevention, and abatement of nonpoint source (NPS) pollution from agricultural and silvicultural activities, administers a certified Water Quality Management Plan (WQMP) Program. The term NPS, as it relates to AFOs, is loosely used to differentiate between AFOs, which do not require written authorization from TCEQ, from point source CAFOs, which do require written authorization under a permit. Because of this understanding, the TSSWCB's WQMP Program is applicable for any AFO not defined as a CAFO. There are approximately 3,000 such AFOs currently operating under the authority of a WQMP certified in accordance with Texas Agriculture Code §201.026. The technical elements of a WQMP are based entirely on the United States Department of Agriculture - Natural Resource Conservation Service's (NRCS) Field Office Technical Guide (FOTG), which is the best available technology and the basis for many of the management practices and agricultural engineering standards incorporated into the permitting program. A certified WQMP developed for an AFO that meets the technical requirements of the FOTG is a CNMP. A WQMP is effectively a conservation plan that includes a functionally equivalent level of environmental protection from a voluntary perspective. As a result, the TSSWCB encourages as many AFOs as possible to voluntarily participate in the WQMP Program, even if they are not explicitly required to obtain permit coverage.

Historically, the dairy and poultry industries have showed significant levels of interest in WQMPs and make up the bulk of the AFOs currently participating. In contrast, limited participation of the pork industry has occurred largely due to logistical and operational issues on smaller operations. Smaller pork facilities generally operate on smaller tracts of land that do not support traditional animal waste management systems such as waste storage ponds, treatment lagoons, and significant expanses of land application acreage. The manure and wastewater is generally applied to adjacent land, which may not provide adequate water quality protection.

Project Goal

This project initiated work to evaluate an alternative wastewater treatment system including manure scraping and offsite hauling and a vegetated treatment area (VTA) that was designed by NRCS to treat runoff and wash water prior to leaving the VTA. This system is compatible with the style of operation of small producers and was designed to function well with minimal management intensity. It is expected that work initiated through this project will demonstrate the potential effectiveness of the alternative system to the regulatory community and unpermitted pork producers, thus encouraging increased participation in the WQMP program. It is further anticipated that this evaluation will provide scientific basis for considerations of the possible inclusion of the system as an approved practice into the WQMP Program.

Site Establishment and Management

Demonstration of the VTA system was conducted at one small pork production facility in Bexar County. Further, evaluation of the VTA system was conducted on three small pork production facilities in Bell, Brazos, and Robertson Counties (Figure 1). At each of these facilities, water quality monitoring stations were established: 1) on a control site (with the exception of the demonstration site) to represent typical rural/agricultural land use, 2) below the pens and barns to quantify water quality leaving the facility prior to treatment in the VTA, and 3) at the VTA outlet to quantify effectiveness of the VTA in treating runoff from washing or rainfall. Rainfall depth, rainfall intensity, and flow were measured for each runoff event (dependent on rainfall at each facility site). Event mean concentrations for *E. coli*, nitrogen and phosphorus were determined for each runoff event where sufficient sample volume was available. The project was designed to allow scientific evaluation of the quality of water entering the VTAs from runoff and washing and the water quality exiting the VTAs. Soil sampling was also conducted to assess the spatial distribution and transport of nutrients within the VTAs.

Figure 1. Locations of VTA Sites

A total of 12 water quality monitoring stations were established across the four VTA sites (Table 1; Figure 2). Eight of the water quality monitoring stations use an H-flume, which provide a stage discharge relationship for accurate flow rate measurement. Two of the stations use an area-velocity sensor installed in a culvert or constructed channel to directly measure flow rate. Each of these 10 stations uses a Teledyne ISCO® Avalanche refrigerated sampler to automatically collect water quality samples and to measure and store flow rate. The final two stations are grab sampling stations. A rain gauge was also installed at each facility to measure precipitation.

Table 1. VTA Sample Sites and Monitoring Frequencies

Station ID	Station Type	Nutrients & Bacteria	Sampling Entity	County
Bell In	VTA In	Weekly grabs+ storm events	ARS	Bell
Bell Out	VTA Out	Weekly grabs + storm events	ARS	Bell
Bell Control	Control	Weekly grabs + storm events	ARS	Bell
Brazos In	VTA In	Weekly grabs + storm events	ARS	Brazos
Brazos Out	VTA Out	Weekly grabs + storm events	ARS	Brazos
Brazos Control	Control	Weekly grabs + storm events	ARS	Brazos
Rob In	VTA In	Weekly grabs + storm events	ARS	Robertson
Rob Out	VTA Out	Weekly grabs + storm events	ARS	Robertson
Rob Control	Control	Weekly grabs + storm events	ARS	Robertson
Bexar Gilt Barn	VTA In	Weekly grabs	GBRA	Bexar
Bexar Nursery	VTA In	Weekly grabs	GBRA	Bexar
Bexar VTA	VTA Out	Weekly grabs + storm events	GBRA	Bexar

Figure 2. **VTA "out" at the Bell County (a), Brazos County (b), and Robertson County (c) sites. Lateral distribution lines were installed below VTA "in" at all of the sites (Brazos County site shown here) (d).**

Preliminary Evaluation of Water Quality

Weekly grab samples were only collected when visible flow was observed as a result of storm water runoff or pen cleaning (wash) events. In addition, following storm events, grab samples were collected at all flowing sites when retrieving runoff samples from automated samplers.

All water samples were analyzed by ARS for dissolved nitrate+nitrite nitrogen (NO3+NO2-N), ammonium nitrogen (NH4-N), and ortho-phosphate (PO4-P) phosphorus, total N and total P. Samples from Bell, Brazos, and Robertson Counties were analyzed by Texas A&M AgriLife Research Soil and Aquatic Research Laboratory (SAML) for *E. coli*. The Guadalupe-Blanco River Authority (GBRA) analyzed samples for *E. coli* from the hog farm in Bexar County.

When flowing, GBRA and ARS collected weekly grab samples at the outlet of each barn and VTA at each of the four cooperating farms. Weekly grab samples were also taken at the control, adjacent grazed pasture site at each of the three evaluation farms. This allowed the capture of events resulting from discharge of processed wastewater from the facilities.

Grab samples were collected 27 times from January through July 2013; however, these sampling events in essence represented flow of drinking water, wash water, and urine, not rain-induced runoff, so such sampling was reduced to focus on runoff events.

GBRA and ARS collected runoff samples at the outlet of each barn, at the VTA outlet, and at the adjacent grazed pasture following runoff events and barn washing. No storm runoff events have occurred on the Bexar County site. Storm samples were collected from the Bell, Brazos, and/or Robertson County sites on the following dates:

- January 9, 2013
- February 10, 2013
- March 10, 2013
- April 3, 2013
- May 9, 2013
- May 16, 2013
- May 21, 2013
- June 3, 2013
- June 10, 2013
- July 15, 2013

Results from the analysis of the preliminary data are outlined in Table 2. At each of the sites, the VTA reduced average *E. coli* concentrations by an order of magnitude (~10 times), which is promising because VTA vegetation was not fully established due to drought conditions. In spite of these reductions, runoff from the VTAs had higher *E. coli* concentrations than the control sites.

Table 2. Summary of preliminary *E. coli* (cfu/100 mL) measurements.

Site	Mean *E. coli* (VTA in)	Mean *E. coli* (VTA out)	Mean *E. coli* (Control)
Bell	7.48E+06	7.51E+05	3.86E+03
Brazos	1.21E+07	1.31E+06	5.48E+04
Robertson	3.96E+04	5.51E+03	4.96E+03

Preliminary Evaluation of Soil Samples

Finally, in order to assess nutrient accumulation and movement within the VTAs, baseline soil samples were also collected throughout each VTA using a sampling grid. ARS collected 20 soil samples from the Bexar County facility, 12 from the Bell County facility, 10 from the Robertson County facility, and 10 from the Brazos County facility. Soil samples were analyzed by ARS for plant available phosphate, mineralizable nitrogen, and total inorganic nitrogen. Figure 3 depicts soil phosphorus data from Bell County as an example. The high concentrations are a remnant from previous manure application along the north side of the field. Future soil sampling will be able to better track the movement and possible accumulation of nutrients in the soil resulting from VTA operation.

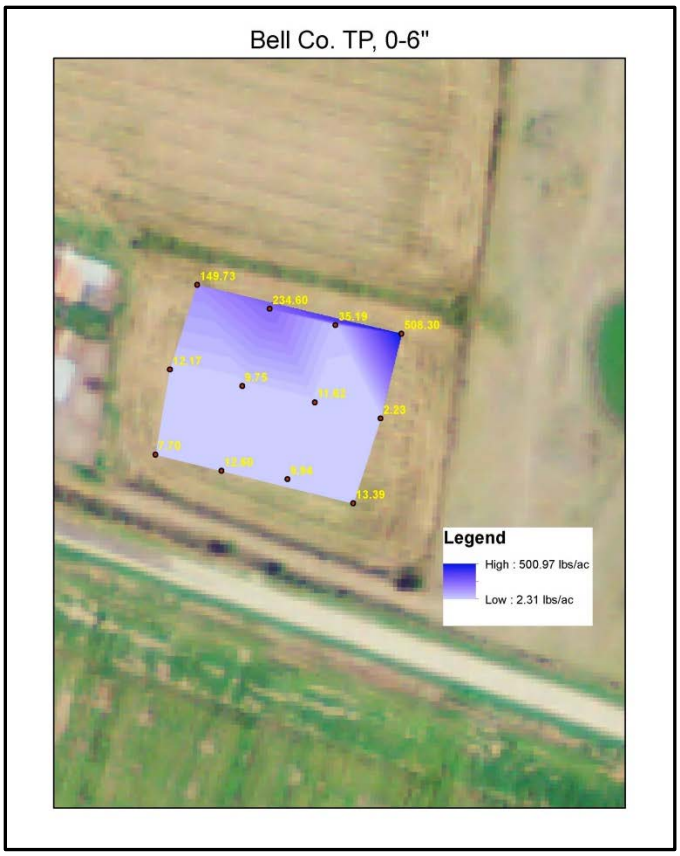

Figure 3. Distribution of total P in the soil at the Bell County site.

Conclusions

Preliminary data collected suggest that VTAs may reduce *E. coli* concentrations by almost an order of magnitude. These preliminary data are encouraging; however, continued assessment of VTA effectiveness in 2013-2015 will provide the robust data required to make a thorough assessment of this practice as an alternative wastewater treatment system for small pork production facilities. At the conclusion of the evaluation, TWRI and USDA-ARS will provide findings to TSSWCB, USDA-NRCS, and others to show the degree of effectiveness of VTAs to protect runoff water quality on small pork production facilities. Final results of the VTA effectiveness will be distributed through outreach materials and producer meetings. If VTA effectiveness is confirmed, TWRI and USDA-ARS will develop a fact sheet summarizing the effectiveness of the VTA practice. USDA-ARS and TWRI will present results to the Pork Producers Association and at State and National meetings. Finally, if VTA use is shown to be an effective practice, TWRI, TSSWCB, and USDA-ARS will work with USDA-NRCS and TCEQ to incorporate results into practice standards and achieve acceptance of this practice for meeting required environmental safeguards.